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CORRESPONDENCE.

ON CERTAIN FORMULÆ IN MR. DAVID JONES'S WORK
ON ANNUITIES.*To the Editor.*

SIR,—I am not aware whether what seems to me to be a serious error in one of the expressions given in Jones's work *On Annuities and Reversionary Payments*, for a deferred assurance, has ever been noticed or not.

On page 170, vol. i., of the work referred to, the general value of a deferred assurance on any number of lives is given as

$$A_{(m, m_1, m_2, \&c.)}^v = r^{t+1} p_{(m, m_1, m_2, \&c.)}^v - (1-r) a_{(m, m_1, m_2, \&c.)}^v. \quad (1)$$

An expression correct enough: but wishing, I presume, to give this result in a more convenient form, the author goes on to manipulate the latter term of the second member of this equation, thus—

$$(1-r) a_{(m, m_1, m_2, \&c.)}^v = (1-r)^t p_{(m, m_1, m_2, \&c.)}^v \cdot a_{(m+t, m_1+t, m_2+t, \&c.)}^v;$$

and in this way he deduces

$$A_{(m, m_1, m_2, \&c.)}^v = r^t p_{(m, m_1, m_2, \&c.)}^v \cdot A_{(m+t, m_1+t, m_2+t, \&c.)}^v. \quad (2)$$

This latter expression it seems to me is quite erroneous, in consequence of a fatal error in the process that leads to it. In fact, $(1-r)^t p_{(m, m_1, m_2, \&c.)}^v \cdot a_{(m+t, m_1+t, m_2+t, \&c.)}^v$ is not (except in the single case when $v = m + m_1 + m_2 + \&c.$)
= number of lives
the equivalent of $(1-r) a_{(m, m_1, m_2, \&c.)}^v$, as assumed in the work referred to.

This will at once be seen if we particularise the expression. Suppose two lives (m and m_1) concerned, and $v=1$; then

$$\begin{aligned} (1-r) a_{(m, m_1)}^1 &= (1-r) (a_m + a_{m_1} - a_{m, m_1}) \\ &= r^t (1-r) \left(\frac{l_{m+t}}{l_m} a_{m+t} + \frac{l_{m_1+t}}{l_{m_1}} a_{m_1+t} - \frac{l_{m+t} l_{m_1+t}}{l_m l_{m_1}} a_{m+t, m_1+t} \right), \end{aligned}$$

while

$$(1-r)^t p_{(m, m_1)}^1 a_{m+t, m_1+t}^1 = r^t (1-r) \left(\frac{l_{m+t}}{l_m} + \frac{l_{m_1+t}}{l_{m_1}} - \frac{l_{m+t} l_{m_1+t}}{l_m l_{m_1}} \right) (a_{m+t} + a_{m_1+t} - a_{m+t, m_1+t});$$

a very different expression indeed, and giving rise to a very serious error.

As an illustration, let us take an actual case:—Required the single premium for £1 payable on death of last of two parties now aged 30 and 40 respectively, provided that event happens after 10 years (Carlisle 3 per cent.)

The true value, *i.e.*, the result of equation (1) is .3118

while the value given by equation (2) is .2959

a result too little by nearly 2 per cent.

Hoping you will be good enough to inform me whether this point has ever been remarked on previously,

I am, Sir, your most obedient servant,

JAMES R. MACFADYEN.

*City of Glasgow Life Assurance Company,
Glasgow, 18th July, 1866.*